Office of Naval Research International Field Office

Newsletter

Synthetic Aperture Sonar and Radar Research at University College London

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Keywords

Synthetic Aperture Sonar, Bistatic Radar, Stealth Defeating Radar

1. Summary

The Authors visited University College London(UCL) to review sonar and radar research activities. This visit was arranged following a UCL presentation at the Institute of Acoustics meeting earlier in 2002 at Salford University.

2. Introduction

UCL is a constituent part of the University of London. It was founded in 1826 as a stock company. At that time the two existing English universities, Oxford and Cambridge, required membership in the Church of England and the new university was denied a Royal Charter because of its refusal to teach religious classes. It was the first English institute of higher education to admit students irrespective of race, class or religion and in 1878 became the first to admit women. Kings College and Imperial College were founded in 1829 and 1908 respectively. All three colleges and several others are now affiliated in the University of London. Sonar and radar work at UCL are both conducted within the Department of Electronic and Electrical Engineering. The authors met with Dr. Trevor Sutton, a research fellow working on sonar and Professor Hugh Griffiths, the Head of the Department. Prof. Griffiths is a well-known radar researcher and heads the Department's radar work. He is also involved with image processing and works closely with QinetiQ Bincleaves (Doug Carmichael) and Winfrith (Garry Heald).

3. Synthetic Aperture Sonar (SAS)

SAS has long beguiled sonar researchers looking for a way to image stationary objects in the ocean at longer ranges and resolution than can be achieved using real aperture sonars. Synthetic aperture radar (SAR) is well developed and very high quality images from airplanes and low earth orbit satellites, obtained using SAR, are routine. The technical difficulty that has slowed the development of SAS has to do with the difference in speed of propagation of sound in the sea (1500m/sec), as compared to electromagnetic waves in air or space ($3x10^8$m/sec). Basically, even at long ranges the round trip travel time of an electromagnetic wave is so short that the motion of the transmitting platform as a fraction of the transmitted wavelength is insignificant, whereas in the sonar case accounting for the platform motion has proven difficult. Furthermore with SAS, the variability in the propagation path needs to be taken into consideration.

Synthetic aperture processing in both sonar and radar takes account of the phase of the received signal. Uncertainties in platform position of even a tenth of a wavelength cause degradation of the synthetic aperture image. For mine hunting operations etc, these sonars are usually looking for fairly small targets and therefore the frequencies used are routinely in the 100kHz+ range. At these frequencies, wavelengths are very short (15cm) and even millimeter errors in projector location on successive pings can lead to image blurring. Additionally, these side look sonars are often mounted on towed bodies, which further complicates the location issue. Because of this projector location uncertainty, much of the development work on SAS has been conducted on bottom-mounted rails and high quality images have been obtained.

UCL, working with QinetiQ, Thales and BAE Systems, has done research on SAS image analysis using data obtained from an unmanned underwater vehicle (UUV). They have addressed the projector motion problem using a motion compensation scheme based on a displaced phase center algorithm (DPCA). This method forms phase centers between the projector and each receive hydrophone for each ping epoch and then correlates the signal response for successive ping epochs. This method can detect and correct for previously unknown sub millimeter projector movement. Dr. Steve Borchard and his US colleagues at DTI developed DPCA. It has also been further developed by Dr. Marc Pinto (pinto@saclantc.nato.int) at SACLANTCEN, La Spezia, Italy. UCL also has worked to further improve the image with an autofocus method called phase gradient autofocus (PGA) that minimizes phase errors. The best results that they showed were clear images of meter size cylinders and spheres taken from a UUV at 262 meters range. The need for overlap in the phase centers between successive pings limits the speed through the water.

Comparable work is being conduced by Heriot-Watt University. Scotland (Ron McHugh, rmc@cee.hw.ac.uk) and the University of Canterbury, New Zealand (Peter Gough, p.gough@elec.canterbury.ac.nz).

4. UCL Radar Research

Prof Hugh Griffith is a long time radar researcher whose present interest is in bistatic radar using emitters of opportunity. These emitters can include cellular telephone base station signals, TV signals and other convenient emitters. Bistatic radar is especially useful as an anti-stealth technique because it can potentially detect reflections from the stealth vehicle in directions away from the emitter. Prof. Griffith is well known in both the UK and US for his radar work and has current support from the European Office of Aerospace Research and Development (EOARD). His briefing was considerably shorter than the SAS brief and my impression was that this work is well known in the US. However, ONRIFO will conduct a follow-up visit (Ref; W Miceli) to look further at the radar work.

5. Assessment

The SAS work that we observed was the best that the authors have personally seen. The techniques used (DPCA and PGA) are not unique and in the case of, at least, DPCA were initially developed in the US. There may be potential to improve the rate of area coverage, which at present is dictated by range and tow speed through the water, using pulse discrimination techniques and pulse overlap.

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